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Pinus tabulaeformis

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Arboretum Activities

THE STAFF

The Director has for several years been a member of the Visiting Committee for the Arnold Arboretum of Harvard University. Twice each year (in early May and October) the members of this Committee spend a day at the Arboretum in Jamaica Plains, Mass., inspecting the plantings and learning of work in progress. Because of the close association which has long existed between the Morris Arboretum and the Arnold this opportunity for a continuing intimate relationship is greatly valued.

Dr. H. L. Li, Taxonomist, has recently returned from two months in the Far East where he was continuing his studies on the trees and shrubs of Formosa. After visiting Hong Kong and Formosa, each for about a week, Dr. Li went on to Japan where he spent the major portion of his time studying in the herbarium at Tokyo University. He also worked for a while with the collections at Kyoto. In a future issue of the Bulletin Dr. Li will give an account of some of the botanical highlights of his trip.

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Hard Pines Cultivated in the Philadelphia Area

JONATHAN W. WRIGHT AND FRANK S. SANTAMOUR, JR.[1]

INTRODUCTION

Pinus is the largest and most important genus of conifers. In fact it is one of the half dozen most important plant genera in the world. The pines produce much more than the knotty pine panelling with which we decorate our recreation rooms. They furnish the majority of the lumber used in house construction — the beams which support the floors, the rafters in the roof and the joists in the walls. They may also supply sub-flooring, flooring, and siding. The majority of our telephone and power line poles are made from pine trees. Pine wood pulp is the mainstay of the southern pulp industry which supplies the raw material for newspapers, facial tissues, cardboard cartons, and rayon clothing. Large quantities of pine piling are used to support houses, office buildings, and harbor works. And the southern pine naval stores industry furnishes turpentine and resin. If all pine products were to be suddenly taken away from us, we should probably have to revise our living habits just as much as if we were suddenly to lose our automobiles.

The landscape possibilities of the genus are equally varied. No pine can furnish the pretty flowers of the rose or the red autumn foliage of the maple. But the evergreen foliage and the varied trunk sizes and shapes furnish backgrounds against which to display summer flowers and may provide all the color there is in the winter garden.

The hard pines, which are the subject of this paper, grow in a variety of shapes and sizes to fulfill many landscaping needs. At one end of the scale is the mugo pine (*P. Mugo* Turra. var. *Mughus* (Scop.) Zenari) which is a shrub that commonly grows only a few feet tall. It is ideal for foundation plantings. The Japanese umbrella pine (*P. densiflora* Sieb. & Zucc. var. *umbraculifera* Mayr.) is another shrubby type. It has yellow-green foliage and a delightfully crooked, orange-red trunk. (Fig. 18). There are several species, for example Virginia (*P. virginiana* Mill.) and Table-Mountain (*P. pungens* Lamb.) pines which form round-topped, much-branched trees 20 to 40 feet tall when open-grown. They can form the focal point for groupings of shrubs and flowers in small gardens. Lastly there are the many species such as red (*P. resinosa* Ait.), Scotch (*P. sylvestris* L.), (Fig. 15), European black (*P. nigra* Arnold) (Fig. 16), and ponderosa (*P. ponderosa* Laws.) pines which have straight, single stems and grow to large sizes. They are useful for snowbreaks and shade, and as specimen trees in large gardens and parks.

[1] Dr. Wright is Associate Professor of Forestry, Michigan State University, East Lansing, Michigan. Most of the observations recorded in this paper were made when he was Geneticist at the Northeastern Forest Experiment Station of the U. S. Forest Service (1946-1957). Mr. Santamour is Geneticist, Northeastern Forest Experiment Station, and has been stationed at the Morris Arboretum since 1957. The forest genetics work of the Northeastern Station is in cooperation with the Morris Arboretum of the University of Pennsylvania at Philadelphia, Pennsylvania.

GEOGRAPHIC ORIGINS OF PHILADELPHIA'S HARD PINES

The hard pines are widely distributed in the northern hemisphere. In the New World they occur naturally from Nova Scotia westward across Canada to Alaska, south to Guatemala, and on many of the Caribbean islands. In the Old World their natural range extends from north of the Arctic Circle in Scandinavia and Siberia to Turkey and northern Africa and eastward across Asia to Japan and the Philippines. Their southernmost natural occurrence is a few miles south of the equator in Sumatra. This range has been greatly extended by man's activities and now there are hundreds of thousands of acres of pine plantings in southern Africa, Chile, New Zealand, and Australia.

The forests of the northeastern United States contain eight indigenous hard pines. These are red pine, jack pine (*P. Banksiana* Lamb.) Table-Mountain pine, Virginia pine, shortleaf pine (*P. echinata* Mill.), pitch pine (*P. rigida* Mill.), loblolly pine (*P. Taeda* L.), and pond pine (*P. serotina* Michx.), All of these except the Table-Mountain and pond pines are important timber or pulpwood species in Pennsylvania, New Jersey, and Maryland and all except the pond pine are represented in the Philadelphia area by living, healthy specimens. However, only red pine has been planted to any extent within the city and its suburbs.

The extensive pine forests of the southeastern United States are composed of four principal species — shortleaf pine (New York and southward), loblolly pine (Cape May, New Jersey and

Fig. 15. Scotch pine, *Pinus sylvestris*

southward), longleaf pine (*P. palustris* Mill., Virginia and southward), slash pine (*P. Elliottii* Engelm. var. *Elliottii,* South Carolina to Louisiana), and South Florida slash pine (*P. Elliottii* var. *densa* Little and Dorman). The four northernmost of these species are represented in Philadelphia by living specimens. Neither of the two minor southern pines – pond pine and sand pine (*P. clausa* (Chapm.) Vasey, Florida and Alabama) has been planted here.

In the mountainous forests of the western United States and Canada there are seven hard pine species that have proved hardy in Philadelphia. They are ponderosa pine, lodgepole pine (*P. contorta* Dougl.), Jeffrey pine (*P. Jeffreyi* Grev. & Balf.), Apache pine (*P. Engelmannii* Carr.), Digger pine (*P. Sabiniana* Dougl.), Chihuahua pine (*P. leiophylla* Schiede & Deppee var. *chihuahuana* (Engelm.) (Shaw), and knobcone pine (*P. attenuata* Lemm.). The first four of these, which grow in regions with cold winters, show promise of becoming useful timber and ornamental trees in the Northeast. The newly described Washoe pine (*P. washoensis* Mason & Stockwell) from the mountains of western Nevada has not yet been tested here but will probably prove hardy. Three other native United States species – Monterey pine (*P. radiata* D. Don), bishop pine (*P. muricata* D. Don), and Torrey pine (*P. Torreyana* Parry) – grow naturally in the warmer parts of California or Baja California and probably will not prove hardy in the eastern United States.

The Mexican highlands are the center of genetic diversity in the genus, containing 30 or 40 different pine species. Many are useful timber types within their native ranges and are being planted extensively in the southern hemisphere. Unfortunately they seem to be of little potential value for Pennsylvania conditions. Several years ago we obtained seeds of six Mexican species and grew them in the nursery at the Morris Arboretum. The seed germinated well and the seedlings grew rapidly. But only one seedling survived as long as three years, the majority dying the first winter.

Fig. 16. European black pine, *Pinus nigra*

Fig. 17. Japanese black pine, *Pinus Thunbergii*

The three hard pine species which are most commonly planted in this area are introductions from northern and central Europe. These are Scotch pine, Austrian pine (*P. nigra* Arnold var. *austriaca* (Hoess) Aschers. & Graebn.), and mugo pine. Only a single specimen of *P. Heldreichii* Christ from the mountains of Greece is known to exist in this area. The cluster pine (*P. Pinaster* Ait.) is a recent introduction from Spain and Morocco. It has proved unexpectedly hardy and fast-growing. The sixth native European species, Aleppo pine (*P. halepensis* Mill.), lasted only one growing season when tested at the Morris Arboretum several years ago. The nut pine (*P. pinea* L.) from the shores of the Mediterranean Sea is still untested in Pennsylvania.

Japan, which is a center of diversity for many genera, contains only two hard pine species — Japanese red pine (*P. densiflora* Sieb. & Zucc.) and Japanese black pine (*P. Thunbergii* Parl.). (Fig. 17). Both are well adapted to Philadelphia conditions. They grow rapidly and produce seed at an early age and also reproduce naturally in several situations.

China, like Japan, is relatively poor in pine species. The Chinese pine (*P. tabulaeformis* Carr.) is a wide ranging and variable species from the mountains of western China. In Philadelphia it is represented by a few specimens, some of which show considerable promise as timber trees. (Fig. 19). The Masson pine (*P. Massoniana* Lamb.) and Yunnan pine (*P. yunnanenis* Franchet) are doubtfully present in this area. The specimens in the Morris Arboretum certainly contain germplasm of the two species in question but may be interspecific hybrids rather than the pure species. (Fig. 20).

The remaining hard pine species (about six in number) are natives of warm regions such as the Canary Islands, the Ryukyu Islands, Formosa, the Philippines, southeast Asia, Sumatra, India, and Pakistan. There are no records of their having been tried in Philadelphia and only the chir (*P. longifolia* Roxb.) from the mountains of India and Pakistan is likely to prove hardy here.

To sum up, most of the successful hard pine introductions have come from the northeastern United States, the mountainous parts of the western United States, northern and Central Europe, Japan, and Western China. For the most part the many species native to the southeastern United States, coastal California, Mexico, the coastal areas around the Mediterranean, and southeastern Asia are not hardy in our area.

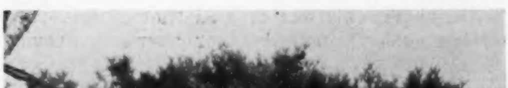


Fig. 18. Japanese umbrella pine,
Pinus densiflora var. *umbraculifera*

Racial Variation in the Hard Pines

About 140 years ago Roger Vilmorin, a French seedsman, obtained seeds of Scotch pine from different parts of the species' natural range and grew the resulting seedlings on his estate near Nancy, France. He then transplanted the seedlings to as nearly a uniform a site as he could find. These plantings form the nucleus of the present Arboretum des Barres. But, more pertinent to the present discussion is the fact that his tests showed the immense amount of genetic variation contained within a single Linnaean species. Some of his origins grew twice as fast as others, and there were important differences in cone size, needle color, and trunk form.

Vilmorin's results were published in 1857. They prompted other European investigators to undertake similar studies. By the end of the 19th century the presence of racial variability had been established in several European species and it was common practice for European foresters to specify the general areas from which they wished to obtain seed for planting in a certain locality. However, it was not until the mid-1920's that American foresters became seriously interested in the problem of racial variability. At that time a small seed origin study of loblolly pine was established in Louisiana. Like its European forerunners, this test showed that growth rate, disease resistance, and other characters varied with the locality from which the seed was collected. By 1950 seed origin studies were under way in about 15 different hard pine species and planned in several others (Schütt, 1958). In all but one of these 15 species the presence of genetic differences has been demonstrated. Here we can mention only a few of the most important studies dealing with species that are commonly planted in the area.

Fig. 19. Chinese pine, *Pinus tabulaeformis*

The importance of seed origin in forest trees is best illustrated by reference to data from a 17-year-old Scotch pine planting in southern New Hampshire (Wright and Baldwin, 1957). This planting was established in 1938 as part of a cooperative international test and contains trees from 55 different localities in northern and central Europe. Each of these localities was represented by two or more plots of trees, so that we can be sure that the reported differences are due to the origin of the seed and not to soil differences. The trees were measured in 1955, during their 18th growing season. The following tabulation shows the most important characteristics of some of these seed origins at that time (all differences shown are statistically significant).

Locality of origin	Height	Trunk straight-ness	Winter foliage color
	Feet		
Northern Norway	6	Straight	Yellow
Southern Sweden	14	Straight	Yellow-green
Latvia	19	Straight	Green
Germany	20	Crooked	Green
Belgium	23	Crooked	Blue-green

The Latvian stock is best from the forester's standpoint because of its moderately rapid growth and straight stems. That stock is also good for Christmas tree growers although many people prefer the slightly bluer Belgian trees.

Several small seed origin studies conducted with the European black pine indicate that it is just as variable as the Scotch pine. Several years ago we tested nine different European black pine seedlots in the Northeastern Forest Experiment Station's experimental nursery at the Morris Arboretum and could probably have described nine different varieties had we been so inclined. At the end of 2 years some seedlots were only 3 inches tall and had straight needles. Some were 6 or 7 inches tall and had straight needles. Others were 8 or 9 inches tall and had curly needles. No wonder that 105 different scientific names have been proposed for parts of this one species! At the present time only the Austrian variety of this species is commonly planted in the United States, but some of the other varieties may prove to be far more satisfactory.

Fig. 20. Masson pine, *Pinus Massoniana*

A recently established seed origin test of jack pine is now in its sixth growing season. Already this test has produced one astonishing result. Trees from Michigan's lower peninsula grow about 20% faster than do trees from Michigan's upper peninsula even though the two populations are separated only by the narrow Mackinac Straits. Differences in resistance to insect pests were also noted.

Most of our knowledge concerning racial variability in the western ponderosa pine was obtained from a 20-year-old planting established in northern Idaho. In that test trees from western Montana (21 feet tall, 4.6 inches diameter breast high) grew over twice as tall as did trees from northern New Mexico (10 feet tall, 2.2 inches diameter breast high). Differences as pronounced as these were also evident in trunk form, crown form, needle arrangement, and needle number (Weidman, 1939).

Unfortunately we do not know the geographic origins of many of the trees planted around Philadelphia. They may be among the best or among the worst available in the species. This situation is being remedied rapidly and a decade from now tree planters can expect much better results by planting seed of the best origins of the best species.

Taxonomy and Identification of the Hard Pines

The genus *Pinus* is separated into two subgenera — the soft pines or subgenus HAPLOXYLON and the hard pines or subgenus DIPLOXYLON. Some of the more important characteristics by which these subgenera may be identified are shown in the following tabulation.

	Haploxylon	Diploxylon
Leaf fascicle sheaths	Deciduous	Persistent
Bracts of leaf fascicles	Not decurrent	Decurrent
Fibrovascular bundles per needle	One	Two
Stomata on back of needle?	Usually not	Yes
Umbo on cone scale	Terminal and resinous in many species	Lateral, not resinous
Male flowers formed	Shortly before anthesis	The season before anthesis

The subgenus DIPLOXYLON is further subdivided into several series (seven according to Shaw, 1914, and Rehder, 1940; more according to Martinez, 1948). With a few exceptions these series comprise natural groups of species with common characters and similar geographic ranges. Hybridization studies also indicate the general validity of the series (Duffield, 1952; Wright and Gabriel, 1958). Nearly all attempted crosses involving members of different series have failed (the exceptions are *P. echinata* × *P. rigida* and *P. Jeffreyi* × *P. Coulteri*) whereas a large percentage of the crosses made within series have succeeded.

Most current estimates place the number of species in the genus at between 80 and 90. If anything these estimates are too low. There is considerable merit in recognizing some entities that are now termed geographic varieties or races as distinct species. Such splitting would make for a more uniform species concept in all the conifers. It would also serve a practical purpose by insuring that tree planters paid proper attention to the source of their seed. For example, there is no doubt but what the dwarf (*P. Mugo* Turra. var. *Mughus* (Scop.) Zenari) and erect (*P. Mugo* var. *rostrata* (Ant.) Hoopes) forms of the European mountain pine are genetically different and are useful for different purposes. At present some tree planters make the mistake of ordering one when they want the other. Mistakes of this type would be less common if the two were regarded as separate species.

There are no rigid rules governing the choice of characters to use in identification work. In our own studies, which have been concerned largely with the recognition of young hybrids, we have used foliage odor (useful in distinguishing Japanese red pine, Japanese black pine and their hybrids), bud color, bud diameter (useful in distinguishing *P. Thunbergii* × *P. nigra* from pure *P. Thunbergii*), growth rate, needle number, foliage color, cone color, degree of cone opening, and whether or not the first-year buds were hidden by the needles. Mirov (1946) found

that many pine species could be identified as exactly (but not as quickly) by the chemistry of their turpentines as by structural characters. In other words, diagnostic characters are where you find them, and do not follow any pattern laid down by a consideration of whether or not one type of structure is more stable than another.

Table 1 is a key to the series and species which are now grown in the Philadelphia area. In preparing this key we tried to stress characteristics which are easily visible on young as well as on old trees. The keys were prepared from Little (1957), Martinez (1948), Rehder (1940), Sargent (1905), Shaw (1914), and our personal acquaintance with the species.

Table 1. Key for the identification of series and species of hard pines growing in the Philadelphia area.

Key to Series[2]

A. Cones requiring 3 years for development; leaf-sheaths deciduous; leaves 3 and 4 per bundle. LEIOPHYLLAE

A. Cones requiring 2 years for development; leaf-sheaths persistent; leaves 2 or 3 per bundle.

B. Seeds less than ¾ inch long, shorter than the membranous wings.

C. Cones unarmed, 1 to 4 inches long, dehiscent at maturity and easily detached from the branch; leaves 2 per bundle (except in *P. yunnanensis*), 2 to 8 inches long; spring shoots uninodal; trees from Eurasia or northeastern United States, inhabiting moderately well drained soils. SYLVESTRES

CC. Cones armed, 2 to 10 inches long, dehiscent at maturity and easily detached from the branch; leaves usually 3 per bundle (except in *P. echinata* and some geographic varieties of other species), 3 to 18 inches long; spring shoots uninodal (western United States species) or multinodal (southeastern United States species). AUSTRALES

CCC. Cones armed (except in *P. Banksiana*), tenaciously persistent and often serotinous, 1 to 6 inches long; leaves 2 or 3 per bundle, 1 to 10 inches long; spring shoots multinodal. INSIGNES

BB. Seeds ¾ inch long, longer than the thick wings. MACROCARPAE

[2] Several characters used in this key apply only to species grown in Philadelphia and not to all species in the series.

Key to Species

A. Leaves 2 per bundle (sometimes 3 in *P. pungens, P. tabulaeformis*).

B. Terminal buds unbranched; spring shoots uninodal; cones opening when mature (except in *P. Pinaster*).

C. Young branchlets covered by bloom, less than ⅛ inch in diameter; leaves slender; cones unarmed, with a weak hold on the branch.

D. Leaves 4 to 8 inches long, yellow-green; rare in the Northeast. *P. Massoniana*

DD. Leaves 3 to 5 inches long, bright green; cones 1½ to 3 inches long, often borne on young trees; staminate catkins yellow, less than ¼ inch long before anthesis; buds brown, non-resinous, with fimbriate scales; bark orange-red; moderately common in Philadelphia. *P. densiflora*

CC. Branchlets without bloom.

D. Cones armed with stout prickles, 3½ to 7 inches long, persistent; leaves 4 to 8 inches long, dark lustrous green; branchlets red brown; buds brown, not resinous; rare in the Northeast. *P. Pinaster*

DD. Cones unarmed, 1 to 3 inches long, usually not persistent or with a weak hold on the branch.

E. Leaves gray-green, 1 to 3 inches long, twisted; buds gray, very resinous; branchlets yellow-gray; cones conic, grayish, with pyramidal apophyses; male catkins yellow, less than ¼ inch long before anthesis; bark orange-red, breaking into thin scales; common in Northeast. *P. sylvestris*

EE. Leaves dark green; male catkins reddish, more than ¼ inch long.

F. Leaves breaking when bent, slender, flexible, not sharp-pointed, 5 to 7 inches long; buds resinous, light brown, frequently killed by shoot moths; bark of old trees red-brown; cones conic-ovid, 1½ to 2½ inches long; common in the Northeast. *P. resinosa*

FF. Leaves not breaking when bent, stout, sharp-pointed.

G. Leaves 1 to 3 inches long.

H. Prostrate shrub or many-stemmed small tree; leaves twisted; cones conic-ovid, lustrous, with pyramidal apophyses; common in northeasttern towns. *P. Mugo*

HH. 1-stemmed tree to 60 feet; leaves incurved; cones ovoid, with swollen apophyses; rare. *P. Heldreichii*

GG. Leaves 2½ to 6 inches long.

H. Buds white, not resinous; leaves 2½ to 4 inches long; cones ovoid, 1½ to 3½ inches long; nut brown, persistent for many years but with a weak hold on the branch; trunk usually crooked; moderately common in Philadelphia. *P. Thunbergii*

HH. Buds light brown; leaves 3½ to 6 inches long.

I. Buds resinous; cones lustrous, light brown, quickly deciduous, with swollen apophyses; large erect tree; common in Northeast. *P. nigra* var. *austriaca*

II. Buds slightly resinous; cones not lustrous, dark brown, with wrinkled apophyses; flat-topped or erect tree; uncommon. *P. tabulaeformis*

BB. Terminal buds branched, resinous; spring shoots multinodal; cones tenaciously persistent; trees bearing cones at early ages.

C. Young branchlets covered by a bloom; cones opening when mature, armed with slender prickles; leaves 1½ to 3 inches long; common in New Jersey but uncommon in Philadelphia. *P. virginiana*

CC. Young branchlets without bloom; cones lustrous.

D. Leaves ¾ to 1½ inches long (longer in seedlings); cones unarmed, asymmetrical, frequently remaining unopened for years, 1 to 2 inches long; common in Pennsylvania forest plantings. *P. Banksiana*

DD. Leaves 1 to 3 inches long; cones armed.

E. Cones armed with very stout prickles, symmetrical, light brown; leaves 1 to 3 inches long; branchlets lustrous orange-brown; uncommon in Philadelphia. *P. pungens*

EE. Cones armed with slender prickles; light yellow-brown, asymmetrical; leaves 1 to 2 inches long; rare in Philadelphia. *P. contorta*

AA. Leaves in bundles of 3 (sometimes 2 in *P. ponderosa, P. Elliottii* and *P. echinata;* 3 to 5 in *P. leiophylla* and *P. Engelmannii*).

B. Terminal buds branched; spring shoots multinodal; cones with sharp prickles; uncommon in southeastern Pennsylvania.

C. Leaves 5 to 10 inches long, branches with slight bloom.

D. Leaves 2 or 3 per bundle, dark green; cones dark lustrous brown, 2 to 6 inches long, stalked. *P. Elliottii* var. *Elliottii*

DD. Leaves 3 per bundle, pale green; cones red-brown, 2½ to 4 inches long. *P. Taeda*

CC. Leaves 3 to 7 inches long.

D. Cones conic-oblong, 3 to 6 inches long, tan, reflexed, asymmetrical, lustrous, not opening at maturity and tenaciously persistent; apophyses conical, ending in stout prickles; branchlets dark orange-brown; trunk without tufts of leaves; rare in the East. *P. attenuata*

DD. Cones conic-ovoid, 1½ to 3 inches long, symmetrical, opening at maturity; apophyses keeled but not conical, armed with slender prickles; trunks frequently adorned with tufts of leaves; trees sprout from base if cut when young; crowns of old trees rounded; common in New Jersey but rare in Southeastern Pennsylvania.

E. Leaves slender, 2 or 3 per bundle; young branchlets with a bloom; cones dull brown; has a straighter trunk, finer branches, and lighter bark than *P. rigida.* *P. echinata*

EE. Leaves stout, 3 per bundle; branchlets lustrous chocolate brown; cones lustrous light-brown; comcommonly with large branches. *P. rigida*

BB. Terminal buds unbranched; spring shoots uninodal.

C. Leaves 3 to 4 per bundle, 2½ to 4½ inches long, leaf sheaths deciduous; cones 1½ to 2½ inches long, stalked, requiring 3 years to develop, persistent, lightly armed; rare in the Northeast. *P. leiophylla* var. *chihuahuana*

CC. Leaf sheaths persistent; cones requiring 2 years to develop.

D. Leaves 8 to 18 inches long, dark-green; buds large, white, not resinous; trees having few branches; rare north of Virginia. *P. palustris*

DD. Leaves 4 to 12 inches long.

E. Branchlets covered by a bloom.

F. Branchlets less than $\frac{1}{4}$ inch in diameter; leaves dark green, 4 to 6 inches long; cones 2 to 4 inches long, lustrous, dark brown, without prickles; very rare in the Northeast. *P. yunnanensis*

FF. Branchlets more than $\frac{1}{4}$ inch in diameter; leaves blue-green, 4 to 12 inches long; cones 6 to 10 inches long, with sharp prickles.

G. Leaves 4 to 9 inches long; not sparse; cones symmetrical, sessile, 6 to 8 inches long, armed with a slender, recurved prickle, dropping without their basal scales; rare in the Northeast. *P. Jeffreyi*

GG. Leaves pale blue-green, sparse, stout, 8 to 12 inches long; cones massive, stalked, slightly asymmetrical, 6 to 10 inches long, armed with stout, incurved prickles; seeds $\frac{3}{4}$ inches long, dark brown, longer than the wings; very rare in the Northeast. *P. Sabiniana*

EE. Branchlets without a bloom, leaves dark green.

F. Leaves 2 or 3 per bundle, 5 to 11 inches long; cones armed 3 to 6 inches long, often dropping without their basal scales, red-brown; taproot of seedlings of same diameter as the stem, the seedling stem elongating each year of growth. *P. ponderosa*

FF. Leaves 3 to 5 per bundle, 5 to 7 inches long; cones 5 to 7 inches long, yellow-brown; seedlings with a thickened taproot and with a stem which elongates very little for several years. *P. Engelmannii*

Synopsis By Species

Table 2 includes the dimensions of the largest specimen which we have measured of each species now growing in the Philadelphia area. This method of presentation probably gives a truer picture of each species' potentialities than would presentation of the dimensions of the average tree because many of the trees are believed to be of inferior seed origin and others were certainly planted on below-optimum sites. In that table and in the textual comments which follow the species have been grouped by series and by geographic origin, in order that those with the greatest number of characteristics in common can be studied together.

Series Sylvestres

This is the most useful series for Pennsylvania foresters and horticulturists. It includes the American red Pine, the three most commonly planted European species, and those Asiatic species which are hardy in our area. Nearly all these species are desirable from horticultural standpoint and several seem destined to become important timber trees in Pennsylvania. The potentialities of the group are only partially explored. Recent hybridization studies have shown that many hybrid combinations involving the European and Asiatic members of the series can be made in quantity and that some of these grow much faster than the parent species. Within the next quarter century we shall probably be using a great many of these hybrids as well as the pure species mentioned here.

Red Pine

(*P. resinosa* Ait.)

Red pine, which derives its common name from the red bark found on older trees, is a tree of our northern forests. It is native from Nova Scotia west to Minnesota and south to West Virginia. It formerly covered large areas and was one of the species on which the original lumber industry of Maine, Michigan, and Wisconsin was based. Most of those original forests have been cut, and few have reproduced themselves satisfactorily. However, the species is in no danger of dying out because hundreds of thousands of acres of forest plantations have been established. This planting program still continues. For example, over 40,000,000 nursery seedlings are produced each year in the state of Michigan.

This species occasionally grows as tall as 150 feet but heights of 70 or 80 feet are much more common. When grown in the forest it is a beautiful tree, with its red bark and straight, branch-free boles. If an incipient fork occurs in a young tree one stem usually grows slightly faster than the other, which then droops to become a branch. Thus, the mature trees are rarely forked.

Red pine was commonly planted around Philadelphia in the 1930's. A great many of these plantings are now suffering greatly from attacks by the European pine shoot moth (*Rhyacionia buoliana* (Schiff.)), and some have been cut down because of their unsightly appearance. This insect feeds on the buds which produce the next year's growth. If, as sometimes happens, every bud on the tree is killed, many twigs die and the tree's growth is considerably retarded. This species is no longer recommended for planting in warm regions except by owners who are prepared to spray their trees each year. Fortu-

nately, this pest seems to be controlled by long periods of low temperatures and the thousands of acres of plantings in cold areas are still relatively free from attack.

Red pine is particular as to the soil on which it grows. It prefers a deep, well-drained soil of moderate fertility, and cannot tolerate soils with a permanently high water table.

Considering the fact that it has a large natural range, this species seems to be very uniform genetically. In seed origin tests which have been conducted in Northern Pennsylvania and in Minnesota the extreme growth rate differences have only been about 10 percent, as compared with differences of 50 percent or more in most species. Red pine also seems to be difficult to hybridize. In spite of years of trials in several different places only one hybrid (with European black pine) has yet been reported.

Scotch Pine
(*P. sylvestris* L.)

Scotch pine is the most widely distributed pine species in Europe or Asia. Its natural range extends from Spain to eastern Siberia and from Turkey to north of the Arctic Circle in Scandinavia. In several north European countries it is the only native pine species and forms extensive forests. Its importance as *the* pine in those countries is reflected by the fact that it is called by a single word in several languages. For example, it is *tall* to the Swedes, *Kiefer* to the Germans, *sosna* to the Russians, and *deal* when imported as wood into English-speaking parts of the British Commonwealth.

The great amount of genetic variability within this species has already been mentioned in the section on racial variability. In the New Hamp-

Table 2. Dimensions of the largest tree of each species measured in Philadelphia arboreta.

Common name	Scientific name, *Pinus*—	Trees measured *Number*	Age *Years*	Total height *Feet*	Height growth per year[3] *Feet*	Diameter breast high *Inches*	Where seen[4]
		SYLVESTRES					
Red	resinosa	15	44	47	1.5	17	H M *W*
Scotch	sylvestris	45	50	58	1.1	21	H *M* W
Austrian	nigra var. austriaca	40	62	65	0.8	18	H M *W*
Mountain	Mugo var. rostrata	2	28	23	0.8	4	*H* W
	Mugo var. Mughus	4	26	7	0.3	—	*H* M W
Balkan	Heldreichii	1	21	20	1.0	7	*H*
Japanese black	Thunbergii	23	36	56	2.0	13	H M *W*
Japanese red	densiflora	24	33	46	2.3	10	H M *W*
Chinese	tabulaeformis	7	45	25	0.6	14	H *M* W
Masson	Massoniana	7	10	10	1.0	2	*M* W
Yunnan	yunnanensis	1	8	9	2.2	2	*M*
		AUSTRALES					
Shortleaf	echinata	5	36	40	1.1	13	H M *W*
Loblolly	Taeda	4	34	50	2.5	13	H M *W*
Longleaf	palustris	1	23	33	1.3	8	*M*
Slash	Elliottii var. Elliottii	1	19	16	0.8	2	*M*
Ponderosa	ponderosa	23	31	32	1.0	11	*H* M W
Jeffrey	Jeffreyi	5	21	18	0.9	7	*H* M W
Apache	Engelmannii	3	9	13	1.8	3	M *W*
		INSIGNES					
Jack	Banksiana	7	23	28	1.0	10	H *M*
Lodgepole	contorta	3	34	18	0.5	6	M *W*
Virginia	virginiana	5	23	28	1.0	9	*H* M
Pitch	rigida	25	56	64	1.4	17	H M *W*
Table-Mountain	pungens	8	44	33	1.2	12	H M *W*
Knobcone	attenuata	1	8	3	0.3	—	
Cluster	Pinaster	12	10	19	2.7	5	*M*
		LEIOPHYLLAE					
Chihuahua	leiophylla var. chihuahuana	2	14	8	0.5	2	*W*
		MACROCARPAE					
Digger	Sabiniana	2	18	18	1.1	8	M *W*

[3] For the past five years.

[4] H = Haverford College, Haverford, Pa.; M = Morris Arboretum; W = Westtown School, Westtown, Pa. Italics indicate the arboretum in which the largest tree is located.

shire study 11 genetically different entities could be recognized, even though the test included origins from only half of the species range. This variation is evident in nearly all parts of the tree—growth rate (4 to 1 differences), seed size ($3\frac{1}{2}$ to 1 differences), cone size, leaf length, winter foliage color, stem straightness (all stems perfectly straight to nearly all stems crooked), and earliness of fruiting. Some of these genetically different races have also been given scientific varietal names and included in standard taxonomic manuals such as Rehder (1940). Perhaps all the races can be so described if the species is ever properly monographed.

This has been one of the most commonly planted conifers in Philadelphia gardens. It is easily recognized by its short, stiff, twisted, and gray-green needles. Trees up to 40 feet tall are common, with occasional specimens reaching 70 feet. (Fig. 15).

In the past decade Scotch pine has become a common Christmas tree in the northern United States. Michigan growers are now planting 30 million trees per year of this one species and Pennsylvania growers are also planting large quantities. In fact the amount planted exceeds the potential Christmas tree cut by such a great amount that Scotch pine will almost certainly be one of our most common timber trees 20 years hence. Growers prefer this species because it is easy to grow, relative free from pests, and can be sheared to produce a regular, full crown. Buyers prefer it (to the extent of paying more per tree for this than for any other common species according to a recent marketing survey in Michigan) because of its short needles, blue-green foliage, and regular crown.

There are no origin data for the older trees planted around the state. We suspect that most of them came from Germany, Poland, or Czechoslovakia. Those are fast-growing, relatively long-needled, and have a tendency to have crooked stems. Occasionally we find trees that appear to be of Latvian provenance; they grow at the rate of $1\frac{1}{4}$ to $1\frac{1}{2}$ feet per year, have shorter needles and smaller branches, and produce straight trunks. There is a small planting at Haverford College which has grown less than 1 foot per year and has very short needles; it appears to be of Swedish origin. During the past few years this situation has changed markedly and most Christmas tree growers now pay a great deal of attention to the seed they order. Preferred origins are Sierra de Guadarama, Spain; Auvergne, France; Scottish highlands; Belgian lowlands (probably from the vicinity of Hagenau, France originally), the foothills of the Alps around Vienna; and Riga, Latvia. A great deal of the so-called "Riga" seed seems to be wrongly named, having come either from East Prussia or Poland.

European Black Pine
(*P. nigra* Arnold)

The European black pine is an introduction from southern Europe, where it grows naturally in the mountains of Spain, Corsica, Italy, Austria, the Balkan Peninsula, the Crimea, and Turkey. It is extremely variable and perhaps should be considered as several different species. Some idea of this variability can be obtained from the fact that over 105 different scientific names have been proposed for all or parts of it one time or another.

In the eastern United States only the Austrian variety (*P. nigra* var. *austriaca* (Hoess) Aschers. & Graebn.) is planted to any extent. This variety is fairly uniform. It has dark green and sharp needles which are about 4 inches long, straight trunks, coarse branches, and a growth rate of 1 to $1\frac{1}{2}$ feet per year. It has been commonly planted in many parts of southeastern Pennsylvania, and trees of all sizes up to 70 feet tall can be found (Fig. 16). In some sections—for example in an old field adjoining St. Thomas Episcopal Church at Whitemarsh—considerable natural reproduction has become established.

In the Morris Arboretum there is a single specimen of the Corsican pine (*P. nigra* var. *Poiretiana* (Ant.) Aschers. & Graebn.). It is now about 30 feet tall and has much smaller branches and a much narrower and more open crown than the common Austrian pine. In Rochester, New York, and Wooster, Ohio are a few specimens of this and other varieties of the European black pine. These show the same diversity of characters that is evident in natural stands in Europe, some growing 1 foot per year and others $2\frac{1}{2}$ feet per year, some having very fine branches and others very coarse branches, some being susceptible to the same pest that is rarely seen on others.

Austrian pine is now being used as a replacement for red pine in the forest planting programs for warmer regions such as southeastern Pennsylvania, New Jersey, and southern Michigan. It grows a little slower and has somewhat coarser branches than the red pine but is greatly superior to that species in resistance to European pine shoot moth and in ability to grow on varied soil types. European results indicate that it will produce about the same type of lumber as red pine.

We have used Austrian pine in our species hybridization program and have obtained two combinations that appear to be exceptionally fast growing and useful under Philadelphia conditions. There are *P. Thunbergii* $\times$ *P. nigra*

and *P. nigra* × *P. densiflora*. Natural hybrids of the latter combination occur frequently in progenies raised from open-pollinated seed collected from Austrian pine that is close to flowering Japanese red pine trees.

Mountain Pine
(*P. Mugo* Turra.)

The mountain pine is a native of the Pyrenees, the Alps, and the high mountains of the Balkan Peninsula. It is an exceptionally variable species. In the Pyrenees it becomes a medium-sized tree up to 75 feet tall (*P. Mugo* var. *rostrata* (Ant.) Hoopes). In the Alps and Balkans it is only a shrub or small tree (*P. Mugo* var. *Mughus* (Scop.) Zenari and *P. Mugo* var. *rotundata* (Link) Hoopes).

The dwarf, shrubby forms are very common in the Philadelphia area. For the most part people plant trees that are only about 1 foot tall and permit them to grow until they are 3 or 4 feet tall and 5 or 6 feet in diameter. The Morris Arboretum formerly had an old specimen which showed the potentialities of the shrub types when allowed to grow. It was more than 5 feet tall and 15 feet across.

On the Haverford College campus are several examples of the erect forms. They are multiple-stemmed, about 20 feet tall, and about half as broad as tall. Seed collected from those plants produced erect seedlings. In some areas such as southern Michigan the erect forms are much more common than the spreading ones.

Balkan Pine
(*P. Heldreichii* Christ.)

Balkan pine is a rare species found in the Balkan Peninsula and southern Italy. It is closely related to the European black pine and is sometimes regarded as a variety of that species. A small tree up to 60 feet tall, it is of relatively little importance in horticulture or forestry.

There is but a single specimen in the Philadelphia area. It is a slow-growing, dark green, dense-crowned tree about 20 feet tall. We still regard our identification of that specimen as tentative, based only on leaf and twig characters, because it has not produced flowers or fruit.

Japanese Black Pine
(*P. Thunbergii* Parl.)

Japanese black pine is a native of Korea and of the three southernmost Japanese Islands. Its native range extends from sea level to 3,000 feet above sea level. It is resistant to salt spray and frequently grows along the beach, assuming the bizarre, windswept forms that are typical of Japanese paintings. These bizarre forms can also be induced by pruning and starvation and for that reason this is a favorite tree among Japanese gardeners. Its usefulness is not limited to horticulture, however, for it is one of Japan's most important timber trees. On favorable sites it attains a height of 120 feet and produces straight sawlogs. It is sometimes found in pure stands but is more common in mixture with trees such as Japanese red pine, camphorwood, cherry, *Zelkova*, or some of the oaks.

This species is fast-growing in eastern Pennsylvania. (Fig. 17). Two-year-old nursery stock is from 8 to 12 inches tall, and growth rates of 2 to 2½ feet per year are common for older specimens. Most older trees have crooked or leaning stems. This tendency to lean seems to be associated with permanent damage to the root systems incurred during transplanting. It is not apparent in the nursery or in natural reproduction which springs up around untended trees but is common in planted specimens.

Japanese black pines start to fruit at a very early age, sometimes when only 3 years old. Trees which are 10 or 15 feet tall may bear 500 cones per year. As in most pines the female strobili are borne at the tip of the new growth. In some trees, however, female strobili appear in place of the male strobili at the base of the new growth. On one tree in which this happened one small twig bore 56 cones. The cones were so crowded that they could not grow to full size or open properly but they did contain good seed.

Northeastern tree breeders are particularly interested in this species because of the ease with which it can be crossed with other species. During the early 1950's workers at the Northeastern Forest Experiment Station produced hundreds of hybrids between this and other members of the series SYLVESTRES such as Japanese red, Austrian, Chinese, Yunnan, and Masson pines. These hybrids are now under test at various locations in this region. The *P. Thunbergii* × *P. densiflora* hybrids are especially promising. They can be produced in quantity by relatively easy techniques and grow faster than either parent. The *P. Thunbergii* × *P. nigra* hybrids are also fast-growing but are harder to produce.

(*To be continued.*)

Weather Sequel: The Winter of 1958-1959

Patricia Allison

One sometimes wonders if all Philadelphia weather is "unusual." In the September issue of The Arboretum Bulletin, a few of the consequences to ornamentals of the drought of 1957, the snow burden of the winter, and the prolonged spring of 1958 were described. The drought killed many plants outright, and weakened many, many more. The abundant snow made up in part for the water deficiency but caused terrible breakage of trees and shrubs, and prevented the application of dormant sprays. The growing season was unusually favorable for fungal pathogens and insects that overwintered in abundance.

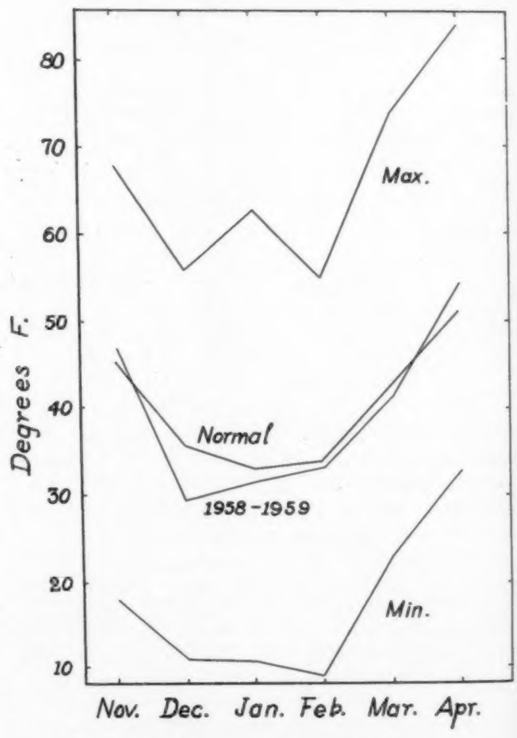
Now we must continue the chronicle, for the winter 1958-1959 was anything but beneficial. It not only prevented recovery from earlier onslaughts, but contributed damage of its own. The winter was cold, yet except for December, with an average temperature 6.5 degrees below normal, it was not exceedingly cold. The winter was dry – exceedingly dry. The winter was bare. Add a sprinkling of contrasting warm days to this winter desert, and the list of offending weather characteristics is complete.

Most of the plant damage was caused by the combination of these four factors that resulted in low soil temperatures and shortage of water at times when loss of moisture from above-ground parts was favored.

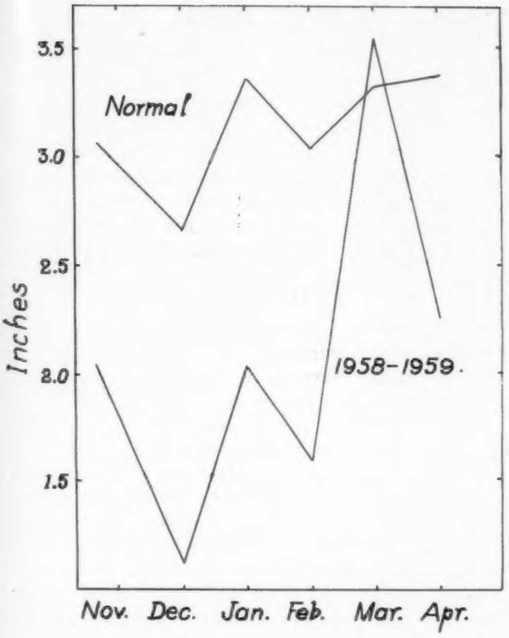
The absence of snow cover was of critical importance. It is known that a relatively mild "weather bureau winter" can be even colder at ground level than a severe "weather bureau winter", since a continuous cover of snow during the latter prevents cooling of the soil. Indeed, differences of 20 degrees are not uncommon between the minimum air temperature and the minimum temperature beneath a snow blanket. Further, it is known that the range between maximum and minimum temperatures is much greater at the soil surface when there is no cover. The total snowfall from November 1 through March was 5.1 inches, the lowest since 1950-1951. Of this, only 0.3 inches were recorded during November and December, and of the 120 days to follow, there were only five for which there is record of more than a trace on the ground. Four of these days were consecutive at the end of January, long after the ground had been cooled in December. (Graph 1.)

What of total precipitation? November was short 1.03 inches; December, 1.54 inches; January, 1.34 inches; February 1.42 inches; April, 1.13 inches. March had 0.23 inches above normal. The total is not encouraging. (Graph 2.) On May 1 we were deficient 6.23 inches of a total normal rainfall of 18.84 inches.

The picture, then, was something like this: The soil cooled early and froze to great depths. At the surface there were extremes of temperature, due not only to normal fluctuations in air temperature, but also to occasional high or low extremes. There was much heaving of the soil as it repeatedly froze and thawed at the surface. Surface vegetation, as ground covers, were damaged directly by freezing, and by root injury caused by heaving of surface oil. In addition, the internal water deficit experienced by larger, deeper rooted plants probably occurred from time to time. This type of internal deficit results



Graph I. Minimum, Maximum, and Average Monthly Temperatures.



Graph II. Total Monthly Precipitation in Inches of Water.

when root systems are unable to replace water lost from a plant through its above-ground parts. It can happen when low soil temperatures cause slowing in root water-transport processes, when root systems are injured, when freezing of soil moisture makes it unavailable to the plant, and when there is a true shortage of water in the soil. Such internal deficiencies frequently become acute in late winter when there are days warm enough to cause rapid water loss from leaves, but not warm enough to affect either roots or availability of moisture in the soil.

This year, damage was widespread among pachysandra, ivy, and myrtle; and especially severe among evergreens such as holly, azalea, Japanese andromeda, and rhododendron. The injury to ivy and some shrubs was obvious very early, but symptoms of internal water deficiency were spectacular later. As late as April, for example, extensive wilting occurred during the heat wave of the second week when the temperature reached 84.2 on the ninth – a new record. The soil was apparently moist, but more water was leaving the plants than the winter-injured root system supplied. Immediate deep watering saved many plants.

Narrow-leafed evergreens were also hard-hit. Yews and junipers were among those reported most damaged. Injury to large deciduous trees has not been obvious except on dry sites. Trees on such sites that were topped last year may not recover. Of all the reports of winterkill received at the Arboretum, most concerned shrubs transplanted in the spring of 1957.

It is hoped that there will not be immediate additions to our weather story. In the meantime, deep watering is highly recommended.

Arboretum Activities

(Continued from page 18)

New Plantings

The early advent of freezing weather last November put an end to most of the work of moving plants from the nurseries to their permanent positions. Although somewhat delayed by the tardy arrival of good planting conditions this Spring, considerable progress has since been made in carrying forward our transplanting plans. Chief among these are the following:

Substantial additions to the beds of Glen Dale Azaleas located along the Hillcrest Avenue side of Azalea Meadow.

Filling in of the early-flowering shrub species in the special collection behind the Gates Building.

Supplementary plantings in the special family groupings on the Bloomfield area across Northwestern Avenue.

Preparation of a small bog garden where for the first time we shall be able to grow plants which require acid bog conditions.

Establishment, east of the Baxter Memorial of an area where most of the Heath Family or Ericaceae (exclusive of Rhododendrons and Azaleas) can be displayed.

Associate Honored

It is with very great pleasure that we report the presentation to Dr. J. J. Willaman of the Superior Service Award of the United States Department of Agriculture. Dr. Willaman is an Associate of the Arboretum and a member of our Advisory Council.

The award, which took the form of a plaque, was made by Secretary of Agriculture Benson at ceremonies held in Washington on Tuesday, May 26. It was given in recognition of Dr. Willaman's distinguished research in plant chemistry conducted at the Eastern Division of the Department of Agriculture at Wyndmoor.

In our Associates' Corner for December 1958 Mrs. Rivinus told something of the work carried on under Dr. Willaman's direction and emphasized the close relationship which has long existed between the Eastern Division and the Morris Arboretum.

J. M. F., Jr.

Associates' Corner

Penn's White Oak of Flourtown

Many historical actions took place under outstanding trees. The Magna Charta was signed under an Oak at Runnymeade, Washington took command of the Continental Army under an Elm, Penn's famous treaty with the Indians was also made under an Elm, to mention but a few of them. Boundary lines were recorded as leading to certain trees in old property deeds. Even Pirate's Gold was buried in relation to prominent trees, and many famous spies and highwaymen were hung to such handy gallows. In more recent times, many of us Chestnut Hillers remember the regular directions for the Main Line, "cross the bridge at Conshohocken, turn left and continue to the big tree."

Their, possibly unconscious, esthetic value has made most men love and thrill at the sight of a great tree.

Pennsylvania, named for its wonderful forests, still possesses living trees that were here to greet Penn, but they are almost daily threatened by Bulldozer Progress. Such a one is the White Oak in Flourtown, just one mile north of Chestnut Hill on East Mill Road and some 400 feet off Route 309.

In 1932 the late Edward E. Wildman, collected records of what he called "Penn Trees" and published them in a book that same year, entitled "Penn's Wood." Only trees of at least 250 years of age were eligible. The Evening Bulletin cooperated voluntarily and published articles asking for reports from individuals knowing of such trees which Dr. Wildman incorporated in his book. The chronicle of the Conservation Department of the State Federation of Pennsylvania Women's State's Historic Trees was added. The Conservation Committee of the New Century Club of Philadelphia and the Schools Committee on Penn Memorials also contributed most effectively. Altogether some 700 Penn Trees were recorded as still standing in 1932, among them the Flourtown White Oak. A bronze tablet was placed on that tree in 1932, at which time its circumference was given as 15 feet; it is now over 16 feet.

Such a mighty bulk was bound to catch the eye of the Bulldozer Boys, ever looking for exercise and allergic to anything green on a map. In 1952 the land on which the Oak stands was sold to Flourtown Homes, Inc., and gleefully the Bulldozer Boys oiled their machines.

Fortunately, there were several heritage-minded neighbors who became aware of the proposed vandalism. Spearheaded by Miss Elsa Ueland, Miss Phoebe Crosby and Mrs. John Newbold and under the chairmanship of Mr. T. Morris Perot the Committee for the Preservation of the William Penn Oak was formed and with the invaluable assistance of Commissioner Elmer Perry, the tree was saved, some surgery performed and feeding and spraying applied. This Committee still functions, but the tree needs attention and funds are running low. It is also very necessary to keep this Committee powerful and alert for Bulldozer. Boys are dangerous animals at all times and, when thwarted can be really vicious and resentful. The Preservation Committee is again stirring interest for more members and contributions.

At the meeting of the Advisory Council of the Arboretum Associates held Friday, May 1, 1959, a resolution was passed heartly endorsing the Preservation Committee's actions, a copy of which was sent to Miss Ueland.

As Associates of an Arboretum, which means "a place in which trees are grown," it is most appropriate that we should do all we can to have a magnificent specimen and an irreplaceable part of our heritage in our very midst.

Marion W. Rivinus

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